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PHYSIOLOGIC ASPECTS OF PORCINE HEMORRHAGE

I. A Vascular Catheter for Chronic Implantation in Swine

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Physiologic Aspects of Porcine Hemorrhage. I. A vascular catheter for chronic implantation in swine– Dixon *et al*

In conducting the research described in this report, the investigation adhered to the "Guide for the Care and Use of Laboratory Animals," as promulgated by the Committee on Revision of the Guide for Laboratory Animal Facilities and Care, Institute of Laboratory Animal Resources, National Research Council.

Joseph P. Marshall J 16 July 81
(Signature and date)

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In this study, a catheter system developed for chronic implantation in dogs was modified and implanted into the cardiovascular system of 50 pigs. Under halothane anesthesia, Silastic(R) and Tygon(R) combination catheters were placed in the ascending aorta via the left common carotid artery of 41 animals; ten of these animals also received a combination catheter placed in the right ventricle via the left internal jugular vein. Nine animals received carotid arterial catheters constructed entirely of Silastic. The catheters were tunneled

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subcutaneously, exited through the skin on the dorsum of the neck, and secured with a Velcro(R) patch. The Velcro patch on the dorsal neck also promoted cleanliness of the exit site, protected the exteriorized catheters from being dislodged by the animal, and provided ready access to the cardiovascular system without need for excessive physical or chemical restraint. Six of the nine catheters constructed entirely of Silastic were classified as failures for a variety of reasons. Only two of the 41 Silastic-Tygon catheters were classified as failures.

ABSTRACT

In this study, a catheter system developed for chronic implantation in dogs was modified and implanted into the cardiovascular system of 50 pigs. Under halothane anesthesia, Silastic(R) and Tygon(R) combination catheters were placed in the ascending aorta via the left common carotid artery of 41 animals; ten of these animals also received a combination catheter placed in the right ventricle via the left internal jugular vein. Nine animals received carotid arterial catheters constructed entirely of Silastic. The catheters were tunneled subcutaneously, exited through the skin on the dorsum of the neck, and secured with a Velcro(R) patch. The Velcro patch on the dorsal neck also promoted cleanliness of the exit site, protected the exteriorized catheters from being dislodged by the animal, and provided ready access to the cardiovascular system without need for excessive physical or chemical restraint. Six of the nine catheters constructed entirely of Silastic were classified as failures for a variety of reasons. Only two of the 41 Silastic-Tygon catheters were classified as failures.

PREFACE

This is the first in a series of reports that will be concerned with the physiological responses of domestic swine to severe hemorrhage. Subsequent reports will be concerned with hemodynamic, acid-base, and blood metabolite changes in the conscious animal during spontaneous recovery from hemorrhagic shock.

We wish to express our appreciation for the conscientious and dedicated technical assistance provided by Marshall F. Jones, SFC; Maria De La Cerda, SSG; Robert J. Hughes, PFC; David Weber, SP4; and Nancy J. Champagne, SP4 in the surgical preparation of the animals, and Diane G. Arevalo for their care during all stages of the study. We are also highly indebted to Ann L. Wilkinson for the numerous hours she spent in typing, proofreading, and assembling the manuscript, and Lottie B. Applewhite for the many editorial and format improvements incorporated in this report.

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Chronic indwelling arterial and venous catheter systems allow immediate access to the vasculature so that multiple blood samples may by obtained, substances may be injected, and physiological variables, such as blood pressure and cardiac output, may be measured in the conscious animal.

The system should meet certain criteria: (1) the design should be simple and allow construction from readily available materials; (2) blood flow should not be totally obstructed in the catheterized vessel; (3) catheter material should faithfully transmit vascular pressure characteristics; (4) the catheter material should not promote clotting on or inside the catheter, hence, allowing prolonged catheter patency; (5) the system should incorporate a reliable but simple method of securing the catheter intravascularly; (6) the catheter should have low tissue reactivity in order to minimize host inflammatory response; (7) the skin exit point should allow easy flushing, opening, and sealing of the system with minimal excitement of the animal; and (8) the system should include a simple procedure for securing the exiting portion of the catheter to the skin and for protecting this portion from being dislodged by the animal.

Various techniques for constructing and implanting vascular catheters for chronic use have been described (1-12). Several methods and devices for chronic exteriorization of indwelling catheters were considered for the present study but they were difficult to construct or were not made of readily available materials (2,3,11). Other potentially useful methods presented catheter termination problems, exteriorization problems, and failure to fulfill the criteria for an ideal system (5,6,7,9,12).

In the present study, the system developed by Mills and Simmons (1) for chronic implantation in dogs was modified for implantation into the cardiovascular system of pigs. Under halothane anesthesia, Silastic(R) and Tygon(R) combination catheters were placed in the ascending aorta via the left common carotid artery, and into the right ventricle of the heart via the left internal jugular vein. Both

catheters were tunneled subcutaneously and exited through the skin on the dorsum of the neck, cranial to the scapulae. Animals were then allowed to recover from anesthesia. This system provided ready access to both arterial and venous systems in unrestrained non-anesthetized animals. The present paper describes the surgical procedure utilized in 50 young domestic pigs.

METHODS

The first catheters used were composed entirely of Silastic(R) medical grade tubing (Dow Corning, 0.040 inches ID x 0.085 inches OD), but these proved to be unsatisfactory because of breaks in the Silastic-Luer lock junction at the exit site. Silastic and Tygon combination catheters were then developed. This design represented a major modification of the Mills and Simmons arterial catheter (1).

Each carotid arterial catheter consisted of three component parts. A 12-cm length of Silastic tubing (Dow Corning, 0.040 inches ID x 0.085 inches OD) was joined to a 60-cm length of Tygon type S45-HL microbore tubing (Norton Plastics, 0.050 inches ID x 0.080 inches OD). To accomplish this, 2 cm of one end of the Silastic tubing was expanded by soaking in xylene for 5 min. The end of the Tygon tubing was quickly telescoped into the expanded Silastic tubing for a length of approximately 2 cm. The xylene was then allowed to evaporate and the Silastic contracted to form a tight junction between the two materials. A 2-cm length of dacron arterial graft material, 1 cm in diameter, was split lengthwise to form a dacron patch. A small hole was placed in the middle of the patch and the Silastic tubing was inserted. The patch was bonded to the catheter with Silastic type A medical adhesive (Dow Corning) at the junction of the Silastic and Tygon tubing (Figure 1A). When the adhesive had cured for 24 hours, the catheter unit was gas sterilized with ethylene oxide.

A total of 50 pigs, 20 to 30 kg body weight, were catheterized. Nine of these animals received a catheter constructed entirely of Silastic, and 41 received the combination Silastic-Tygon catheter. Both types were equipped with a dacron cuff.

Each animal to be catheterized received an intramuscular preanesthetic injection of 0.08 mg/kg atropine, 2.2 mg/kg ketamine HCl, and 1.1 mg/kg xylazine HCl. Anesthesia was induced with halothane through a face mask, and a cuffed endotracheal tube was positioned. Following surgical preparation of the pig, a ventral midline neck incision was made. A 3-cm length of the left common carotid artery was exposed and umbilical tapes were passed around the vessel to control blood flow. A purse-string suture was placed in the adventitia of the carotid artery with a 5-0 Tevdek (Deknatel) cardiovascular suture material. A three-way stopcock was connected to the Tygon end of the catheter with a 16-gauge Luer Stub Adapter (Intramedic) and the system was filled with heparinized saline (1 unit/ml). A small longitudinal incision was

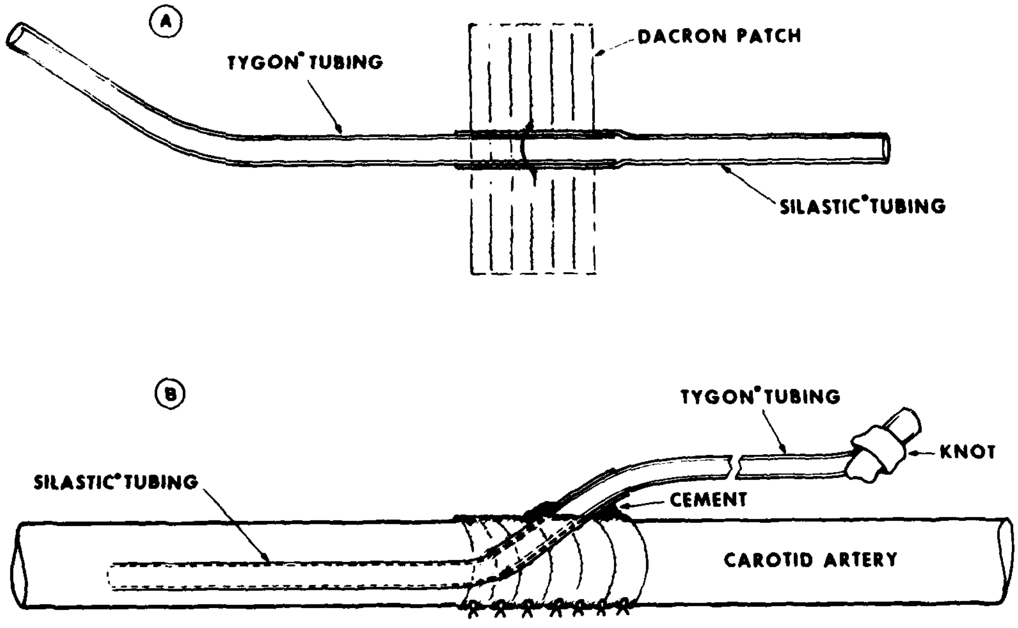

Figure 1. *A (top),* Combination Silastic® / Tygon® vascular catheter with bonded dacron patch.
B (bottom), Carotid artery with combination catheter secured in place with dacron patch suture to form cuff around vessel.

made into the arterial lumen within the purse-string by using a #11 Bard Parker blade. The Silastic portion of the catheter was introduced and advanced to the junction of the dacron patch. The patency of the system was then verified by using a syringe filled with heparinized saline (1 unit/ml). The purse-string suture was tightened to seal the vessel at the point of catheter exit. The dacron patch was wrapped around the artery and the edges were sutured together, forming a cylindrical cuff around the vessel. When free blood flow in the inserted catheter was assured, an overhand knot was placed in the Tygon tubing approximately 5 cm from its free end (Figure 1B). A 15-gauge stainless steel guide wire was passed subcutaneously from the incision site, along the left side of the neck, to exit through a small skin incision on the midline of the dorsum of the neck, 5 cm cranial to the scapulae. The Tygon tubing was then fitted over the distal end of the wire at the

incision site and the tubing was drawn through subcutaneously and exteriorized on the dorsal neck. The original incision was closed routinely in two layers after several sutures were placed around the tubing to provide strain relief and to minimize kinking of the tubing after the animals awakened.

The tubing on the dorsum of the neck was trimmed to a 3-cm length and a 16-gauge Luer Stub Adapter (Intramedic) was inserted into the tubing. A sterile intermittent infusion plug (Argyle) was tightened into the stub adapter and a sealed system was produced (Figure 2A).

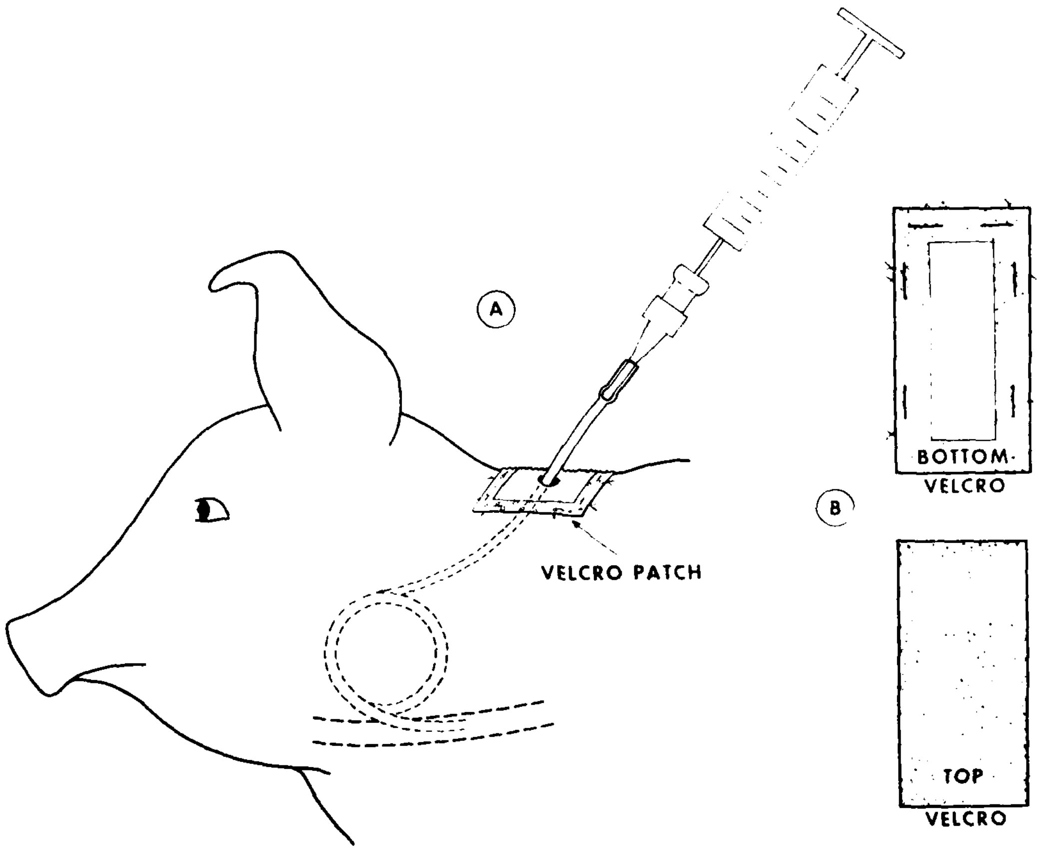

Figure 2. A (left). Animal with vascular catheter inserted and with details of skin exit point.
B (right). Component parts of Velcro® protection patch.

The catheter was flushed with 3 ml of heparinized saline (500 units/ml) utilizing a syringe and 26-gauge needle. A protective covering for the catheter at the dorsal exit site was made from a 2 inch x 4 inch Velcro$^{(R)}$ patch and sutured to the skin using non-absorbable suture material with a wide horizontal mattress pattern (Figure 2B). In addition to carotid artery insertion, a combination catheter was also placed in the right ventricle via the left internal jugular vein in 10 animals. Entrance into the right ventricle was verified with pressure monitoring, utilizing a Statham P23Db transducer and Gould physiological recorder. Procaine penicillin (300,000 IU) and benzathine penicillin (300,000 IU) were given intramuscularly following surgery and the pig was returned to its cage for recovery. The catheters were not cleared of residual blood and heparinized saline between the time of insertion and their subsequent use 1 wk later. When used for physiological studies, the catheters were cleared by applying negative pressure to an attached syringe rather than flushing forward.

RESULTS

Of the 9 cases in which only Silastic catheters were implanted, 2 animals could not be used for subsequent study because the Luer stub adapters spontaneously disconnected postoperatively, and the animals hemorrhaged. On three occasions, the Silastic tubing fractured at the junction of the tubing and the Luer stub adapter, causing spontaneous postoperative hemorrhage. The subcutaneous catheter tunnel became infected in one pig. Because of the problems with catheters constructed entirely of Silastic, all subsequent catheters were the Silastic-Tygon variety.

The combination catheter was implanted in 41 animals. Of these, two failures occurred. Apparently, kinks occurred in the system and blood could not be freely withdrawn. In 37 animals the catheters were in place for one week, at which point cardiovascular studies were conducted. As a test, patency was maintained for two weeks in 3 pigs and in one pig for 5 weeks.

DISCUSSION

The primary advantage of implanting Silastic in the vascular system is that it minimizes clot formation, and any clots that do form do not adhere well to the catheter wall. The dacron used in these studies held the catheter firmly in place within the vessel. The Tygon tubing provided a stiffer, more durable material with which to interface a Luer stub adapter and intermittent infusion device. It also did not fracture from repeated flexion at the stub adapter-tubing junction as did the catheter made entirely from Silastic. Furthermore, it provided more faithful rendition of intravascular pressure transients than Silastic alone. Finally, the Velcro patch on the dorsal neck promoted cleanliness of the exit site, protected the exteriorized

catheters from being dislodged by the animal, yet provided ready access to the cardiovascular system without need for excessive physical restraint.

CONCLUSIONS

None

RECOMMENDATIONS

None

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